

Research article

Development and application of a packer-type drilling-free liner hanger

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Abstract

In liner cementing, the upper cement plug and inner components of a common hanger needs to be drilled out after cementing, which will result in a poor cementing quality or even gas leakage at the flare opening. Therefore, a new packer-type drilling-free liner hanger has been developed, and a hydraulic setting-control packer, a flexible drilling-free seal box, and an auxiliary bearing back-off mechanism that go with the line hanger have been designed at the same time. Specific operation procedures include: (1) run in the liner string to the designed depth, then fully circulate the drilling fluid, finally drop the ball. When the tripping ball gets into the seat, the pressure will go up to cut off the hanging control pin and set the hanger; (2) continue to hold the pressure and cut off the ball seat pin to form circulation; (3) trip in the drill pipe to exert pressure on the hanger, back off to release the hanger from the running tool; (4) lower the drill pipe plug upon the completion of cement injection, cut off the releasing control pin of hollow casing plug, and run down further to bump with the bumping assembly; (5) remove the cementing head and connect the kelly driver, hold pressure again, then slowly pull up the drill tools, exert hydraulic pressure on the setting hydraulic cylinder of the packer assembly to cut off the setting control pin and set the packer; and (6) pull up the tools to the flare opening and wash out excessive cement slurry by circulating to realize free drilling of the whole hole. The successful application of the liner hanger in 127 mm diameter liner in Well BQ203-H1 indicates that the packer-type liner hanger has such advantages as easy hanging and back-off, accurate bumping, simple setting, and sound sealing performance.

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Currently, more and more three-high (high temperature, high pressure, high sulfur content) and three-low (low pressure, low permeability, low productivity) wells are drilled, and liner hanging cementing are commonly adopted in these wells, but the conventional liner hanger without top packer cannot seal the top of the hanger. During the cementing of high-pressure gas layers, as water in the slurry decreases due to hydrate and circulation loss, the pore pressure would decrease and gas could invade into the cement slurry, causing gas channeling and undermining the cementing quality of the upper part [1–6]. If there is a thief zone in the cement section, circulation loss of slurry also will impair the cementing quality

of the upper part; the slurry would flow back if the float collar fails to work, which would affect the cementing quality of the upper part too. Poor top cementing quality is likely to result in gas leakage at the flare opening, which need high-cost and high-risk remedial squeeze repair work [7–10]. For the above reasons, liner cementing, especially in gas wells, usually adopts an upper cement plug, which increases drilling time and flare opening milling time.

Limited by design, conventional liner hangers have small-diameter inner parts which need to be drilled out before the subsequent drilling or completion operation. Drilling out the inner parts would inevitably take time; in small size liner cementing, where a high risk exists, drilling out the inner parts would also harm the annular cement and affect the cementing quality [11–13]. Besides, the back-off of conventional liner hanger, which is a kind of rigid contact, should be realized by accurately locating the neutral point, for which running tool is

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often weighed separately; nevertheless, there are risks of drill pipe sticking, hanging and slipping.

A new $\varnothing 127$ mm packer-type drilling-free liner hanger is introduced in this paper. The successful application of the liner in Wells BQ203-H1 and BM002-X2 indicates that the packer-type liner hanger provides a good solution to the problems mentioned above in liner cementing from the tool technical aspect and improves the cementing process of liner hanger. The hanger features not only easy setting, releasing, annulus pack-off permanently but also bearing back-off, drill-free along the whole bore size and cement plug control, which is of great significance for improving cementing quality and drilling speed.

1. Structure and characteristics of the packer-type drilling-free liner hanger

1.1. Structure

The structure of the $\varnothing 127$ mm packer-type drilling-free liner hanger is shown in Fig. 1, according to its functions, there are the following parts: running tool, a tieback sleeve, bearing back-off mechanism, packer assembly, a flexible seal box, hanging assembly, and a bumping rubber plug system.

- 1) The running tool mainly includes a lifting sub, a sand control cap, a back-off bearing, nuts for bearing fixing, a back-off nut, a core shaft, a connection sub, a flexible seal box, and a lower adapter. Their main functions are to run in the liner, back off and release, seal flexibly, and control packer setting.
- 2) Bearing back-off mechanism, mainly composed of back-off bearing, nut for bearing fixing, back-off nut, core shaft, and hanger back-off sub, functions to back-off and release liner.
- 3) Packer assembly, made up of the body, rubber plug tube group, double expansion ring, retaining ring, packer cylinder, packer control pin etc, functions in pack-off and setting control.
- 4) Flexible seal box, composed of connection pipe, upper adapter, bowl-shaped rubber plug, lower adapter, works to seal the running tool and hanger flexibly, and control the packer setting.
- 5) Hanging assembly, made up of a center pipe, hanger cylinder, piston, control pin, slips, and cones, etc, mainly functions in setting and controlling the hanger.

- 6) Bumping rubber plug system, composed of ball seat, ball seat pin, hollow casing rubber plug, rubber plug releasing control pins, drill pipe rubber plug, and holding pressure ball, functions in setting hanger, bumping, and setting packer.

1.2. Characteristics

In addition to the functions of the conventional liner hanger, this liner hanger has the following unique features in operation:

- 1) It can bear up to 200 kN of dynamic load during back-off operation, and up to 500 kN of static load. Besides easy back-off, it can avoid sticking slip and do not need to weigh the pipe to find out the neutral point, thus saving the weighing time.
- 2) Flexible seal box can be used to control the setting of packer hydraulically. It has re-entry sealing capacity. It can also be reused and have good sealing performance in complex holes after checking release by circulation.
- 3) With flexible seal box installed in the middle-lower part of the running tool, hollow casing plug installed at the rear of the tools, after tripping out the running tool, the hanger is 108 mm in drift diameter without drilling.
- 4) Dislocation filling packer rubber group has efficient sealing for larger annular clearance with a narrow clearance rubber plug under high pressure and temperature.
- 5) Packer double expansion structure can improve the sealing performance with seamless support ring and protect the rubber tube.
- 6) After cementing, the top annular of liner is mechanically packed off forever, preventing gas leakage, circulation loss and backflow. Without top cementing plug left, it can save drilling time and flare opening milling time.

2. Operating principle of the packer-type drilling-free liner hanger

Run in the liner string to the designed depth, then fully circulate the drilling fluid, finally drop the ball. When the tripping ball gets into the seat, the pressure will go up to cut off the hanging control pin, and set the hanger. Continue to hold the pressure and cut off the ball seat pin to form circulation. Trip in the drill pipe to exert pressure on the hanger,

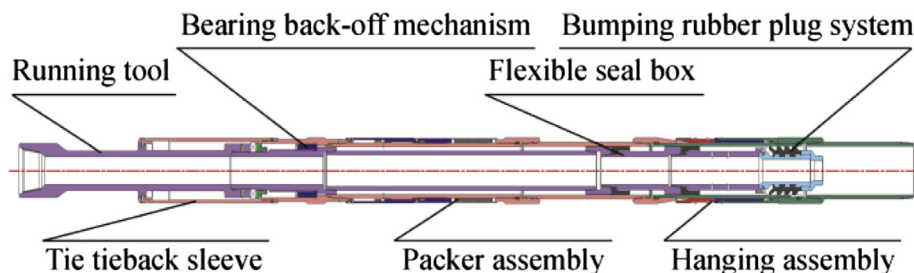


Fig. 1. Packer-type drilling-free liner hanger.

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